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The experience with Wehner/Schulze procedure in the Czech Republic

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Abstract

The paper presents the skid resistance measurements results achieved by Wehner/Schulze method; Christian Doppler Laboratory (TU Vienna) testing device was used.
The Wehner/Schulze testing device is designed to simulate the polishing action of vehicles on road surfaces.
The paper shows a wide scope of W/S method usage: evaluation of polishing of different aggregate fractions, laboratory prepared test specimens and specimens cored from pavements. More testing cycles can predict the long-term development of wearing course friction coefficient.

Keywords: Road surface; skid resistance; surface friction; test method; polishing simulation; aggregate; wearing course; asphalt mixture; Portland-cement concrete pavement

1. Testing device

The so-called Wehner/Schulze (W/S) device developed in Germany 30 years ago is oriented on simulation of traffic impact on road surface and measurement of surface friction. The device is described in prEN 12697-49 [1] and comprises two rotary heads for the specimen surface polishing and the friction measurement. Simulation of accelerated vehicle impact on skid resistance is performed by three rubber rollers rotating on the cylindrical test specimen with a rate 500 rotations per minute (speed 17 km/h). The pressure between the roller and the sample is 0.4 N/mm2 (tyres pressure for passenger cars is about 0.25 N/mm2). The roller slide is 0.5 % to 1.0 %. During the rotation quartz powder is added (2.4 kg in 40 litres water) to polish the sample surface.

Control programme can set the number of rollers travels (usually multiples of 90 000 travels). Subsequently, the specimen surface is washed by clean water using 600 travels of rollers. Then the sample is moved under the

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head used for the friction measurement. The head is equipped with three rubber pads (each with an area 4 cm2). When the head equipped with rubber pads rotates with peripheral velocity of 100 km/h, the head is pressed to the specimen surface. The pressure of the pads is approximately 0.2 N/mm2. These braking pads reduce the peripheral velocity up to a stop of the device during the measurement. The measurement determines the dependence of friction coefficient on speed. The friction coefficient is measured after each required set of roller travels and number of travels can be individually changed. Technical University Berlin established that the procedure ends after 180 000 roller travels. The measured friction coefficient value at the velocity 60 km/h indicates PWS (Polierwert nach Wehner/Schulze = polishing by Wehner/Schulze). [2]

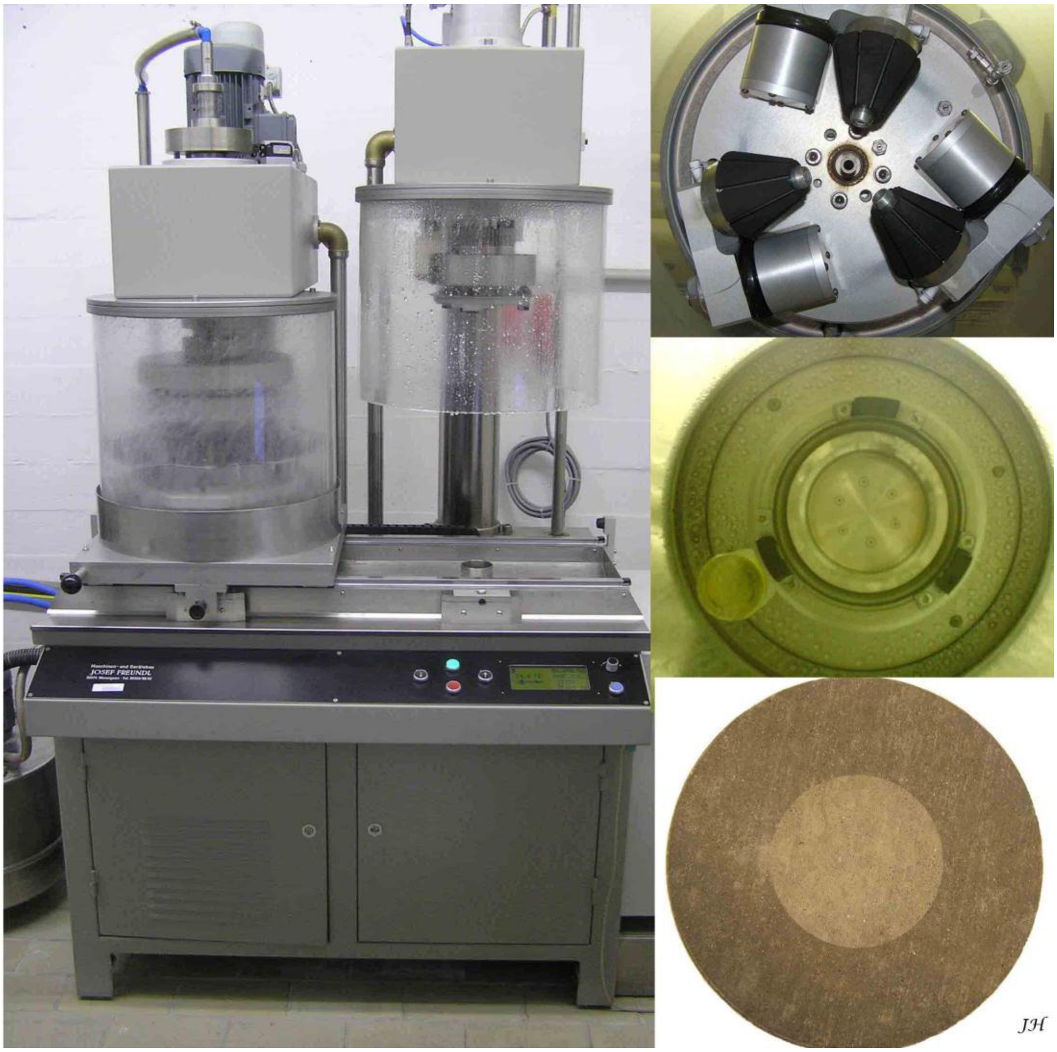

Fig. 1. (a) Wehner/Schulze device; (b) polishing rollers, rubber pads, test specimen [2]

Wehner/Schulze equipment is usually used only for the assessment of the standard procedure described above on the specimens prepared with coarse aggregate or with sand. On the other hand, the accelerated test models the wear effect of road surfaces and the device can be used for the evaluation of different road surface treatments from the point of view of friction coefficient and its durability. We used a measurement method of friction coefficient depending on the number of roller travels that could be similar to the long-term friction measurements of trafficked road surfaces.

Test specimens are cores from the wearing courses with a diameter 225 mm. The specimens can be taken from roads or from laboratory prepared slabs. Currently, there are no requirements for friction coefficient gained by this device; each country will determine them according to their experience with friction coefficient impact on the road safety (traffic accident).

Our measurements were carried out using verified equipment installed in the Christian Doppler Laboratory of Vienna University of Technology. Small sets of measurement persuade us to buy the W/S device and use it in the following research aimed at wearing courses performance testing. The results of performed measurements are described in the following text.

2. Aggregate tests

2.1. Structure

Measurements are carried out according to the standard procedure. The specimens with aggregate are polished by 90 000 travels of rollers and then the friction coefficient values expressed as PWS are determined.

The aggregate - fraction 8/11 mm - is inserted into the mould and a test specimen with a diameter 225 mm is prepared. Single cubic shape grains with straight, flat or smooth sides are stored on a low plate of the mould close to each other. The spaces between aggregate grains are filled in with a sand of a fraction 0.2/0.4 mm to prevent two-component glue flow through the layer of coarse aggregate. The quantities of two ingredients and silica flour filler are mixed together into a homogeneous mass without air bubbles or lumps. The first glue layer is more viscous to stick aggregate grains and the second one is more liquid to create leveled surface of the test specimen bottom. The second layer of glue is applied after an hour and hardens for 5-6 hours. Then the test sample can be removed from the mould, surfaces of test specimens are shown in Figure 2.

Fig. 2. (a) Test specimen of amphibolite aggregate; (b) test specimen of sandstone aggregate;

Measurement results of the main types of aggregate - fractions 8/11 mm - used to wearing courses: sandstone, greywacke, gneiss, granite, basalt, amphibolite and limestone are presented in Table 1, where the results of polishing stone value (PSV) determined according to EN 1097-8 [3] are also presented.

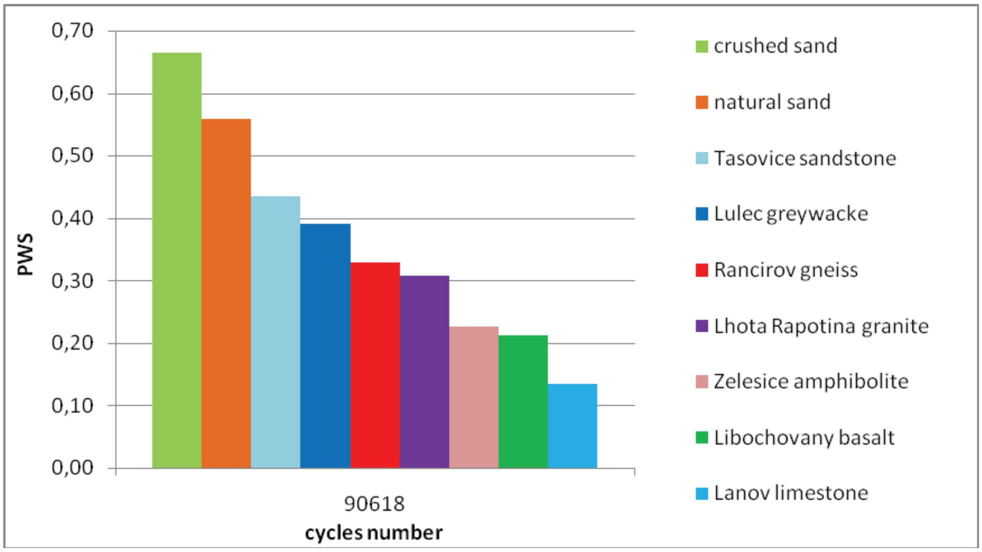

Fig. 3. Aggregate polishing from W/S device

Sand fraction 0/4 mm used to wearing courses of Portland cement concrete (PCC) was applied in PWS tests. The natural sand (round surface of grains) and the same one but crushed sand (percentage of round surface grains is lower than 30 %) were stuck by two-component glue on a wooden plate. The PWS results of sand are presented in the Figure 3 and Table 1, but PSV of the fine materials is not possible to determine.

Good resistances to polishing were measured on sandstone, followed by greywacke, granite and gneiss with PSV values from 54 to 48. Basalt, amphibolite, and limestone are characterized by PSV in the range of 43 to 38. The aggregate characterized by value PSV less than 50 units would not be used in wearing courses for high traffic loading according to the Czech recommendations. The polishing of that aggregate causes low road surface skid resistance during short time traffic using. The dependence of PWS values on PSV values of measured aggregates is presented in Figure 4. The PWS values have better informative ability than offer PSV values. It is known from prof. Huschek TU Berlin publication. [4]

Table 1. Comparison of PSV an d PWS results

Aggregates	PSV	PWS
Amphibolite	49	0,226
Gneiss	52	0,329
Sandstone + amphibolite	53	0,355
Sandstone + granite	54	0,366
Sandstone	55	0,453
Natural sand	-	0,560
Crushed sand	-	0,664

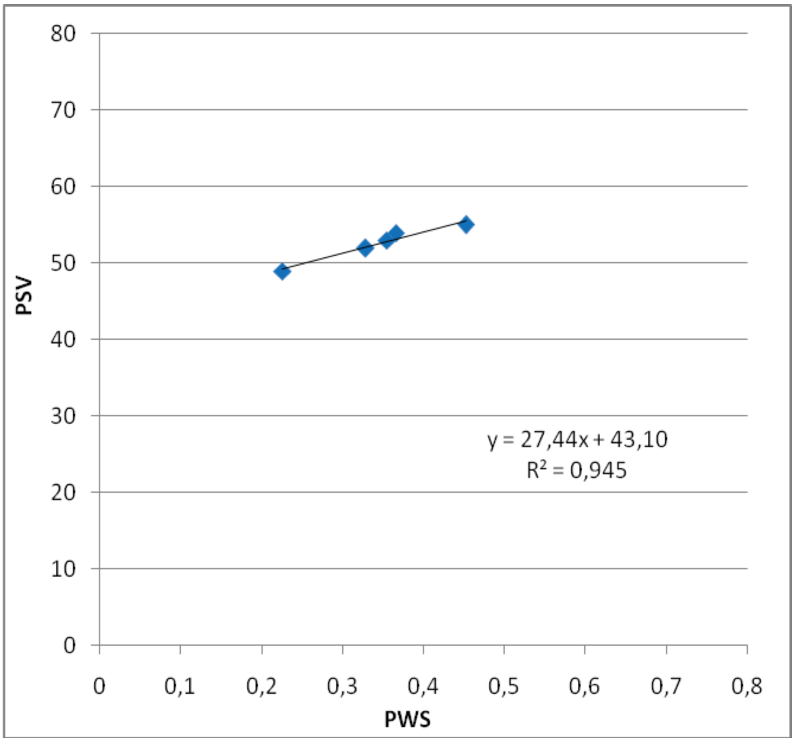

Fig. 4. Correlation of the measurement results with 8/11 mm coarse aggregate applying the two testing methods PSV and PWS

The best PWS results are offered by the crushed sand. Only the surface dressing and slurry seals are able to provide these very good friction properties. The benefit in the PCC pavement depends on surface treatment and mortar quality as will be commented further.

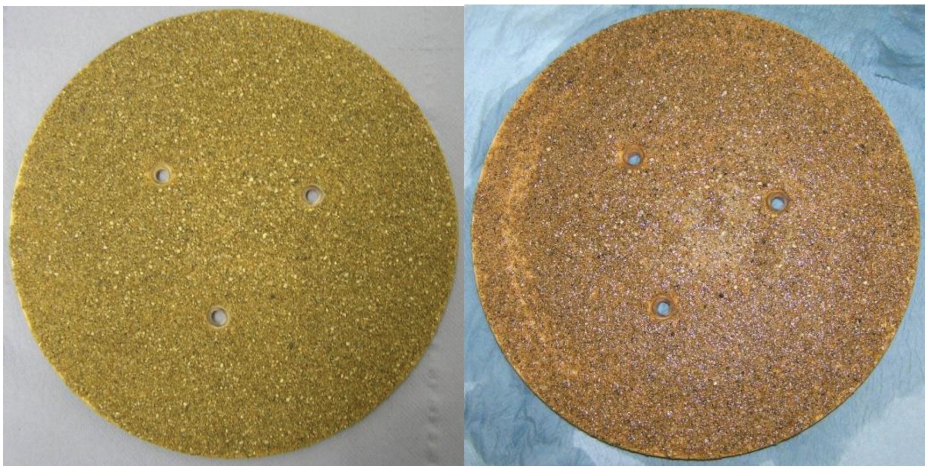

Fig. 5. (a) Sand samples before testing; (b) specimen after one cycle of polishing

3. Wearing courses tests

Different pavements with PCC and bituminous wearing course surfaces were constructed in the Czech Republic. The pavements are new or very old with various types of mixtures and used aggregates. The cores from real pavements were used for measurements.

3.1. Bituminous wearing courses

Sections of highways and expressways of various ages, built between 1995 and 2002 have been selected. Stone mastic asphalt (SMA) or asphalt concrete (AC) wearing courses with maximum grain size 11 mm or 16 mm using different aggregates were used:

- D2 km 25.1 SMA 11, greywacke, 1997,
- D1 km 193.5 SMA 11, greywacke, 1996 (see Figure 6),
- I/38 SMA 11 and AC 11, sandstone, gneiss and mixtures (sandstone with gneiss or amphibolite), 2001-2002,
- D1-D2 SMA 16 amphibolite, 1995 (see Figure 6)

The dependence of decreasing PWS values on number of specimen roller travels are shown in Figure 7.

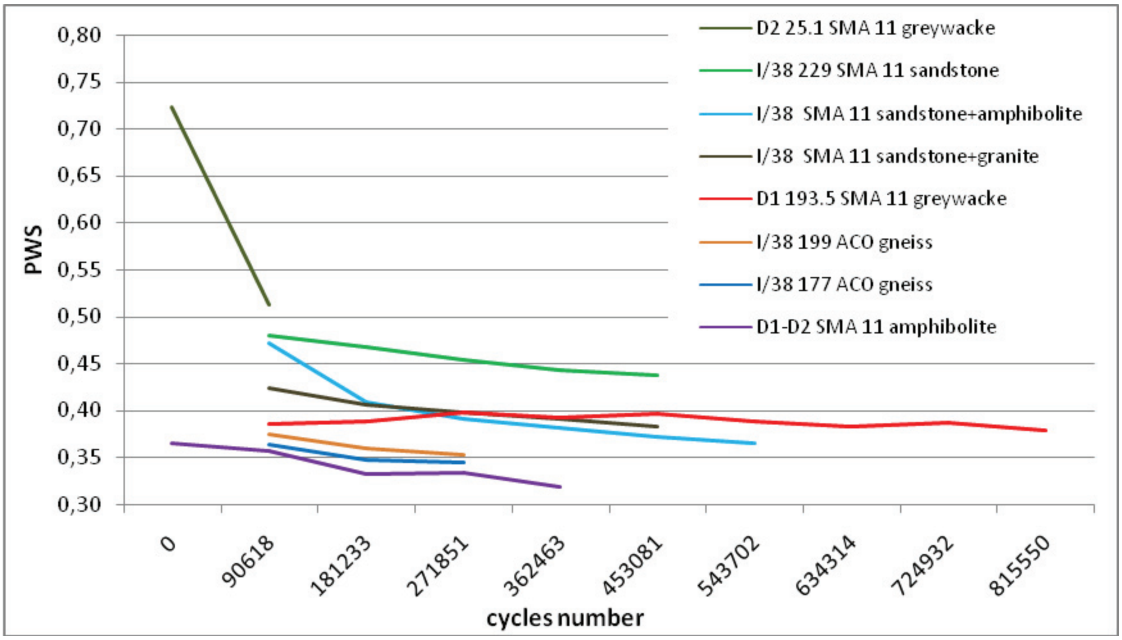

Fig. 7. Dependence of PWS values on cycles for bituminous wearing courses

Fig. 6. (a) Wearing course sample from highways D1 km 193,5; (b) sample from D1xD2

3.2. Comparison of PWS results of bituminous wearing courses and aggregate

Cores taken from SMA wearing courses (from shoulders or non-trafficked surface) were long term tested in the W/S device with repeating loading cycles as is shown in Figure 7. The measurements were focused on the assessment of mixed aggregates with different polishing. Four aggregates were chosen, three were obtained by dissolving the cores taken from the trafficked pavements and one was taken in the quarry. Samples prepared of aggregates obtained by dissolving of the core are marked "C" and a sample made of quarried aggregate is marked “Q”. PWS results of these aggregates were compared with the results of the same asphalt courses.

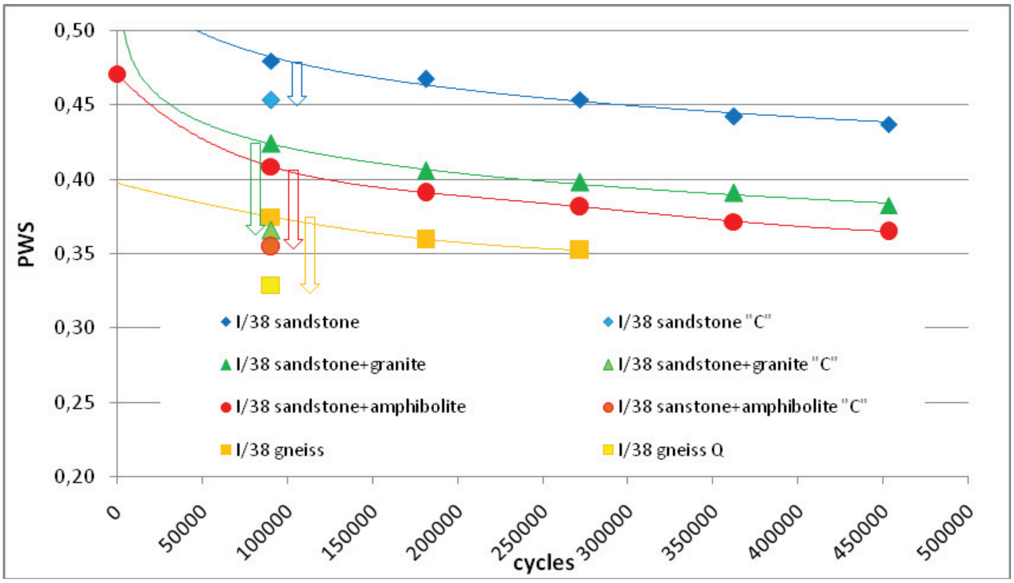

Fig.. 8 The comparison of SMA specimens with aggregates coming from dissolved samples

The results of wearing course measurements presented in Figure 8 reliably and reasonably reflect the influence of aggregate on the whole mixture and the friction coefficient (PWS) of the road surface. Aggregate PWS gives a small different result. Sometimes the aggregate PWS results can forecast more optimistic behaviour of the wearing course PWS long-term development (in case of sandstone) and the opposite lower PWS long-term development of wearing course (in case of the other aggregates). It means the testing of real mixtures will be preferred.

3.3. PCC pavements

The goal of the measurement was to assess the existing concrete road surfaces that were built between 1971 and 2005 offer low and high skid resistance. PCC pavements with different surface treatment (burlap drag, broomed and grooved surface) and various aggregates were monitored.

Burlap drag surface – D1 km 228.313 (1997, gravel sand, granodiorite), D1 km 241 (2005, gravel sand, greywacke), D1 km 245 (2005, gravel sand, greywacke), D1 km 250 (2005, gravel sand, greywacke), D5 km 136.6 (1994, gravel sand, spilite), D5 km 92.2 (1994, gravel sand, spilite), D11 km 37 (1999, gravel sand, gneiss), R35 km 281 (1997, gravel sand, greywacke),

Broomed surface - D1 km 175.3 (1971, gravel sand, limestone, granite), D1 km 177.2 (1971, gravel sand, limestone, granite), D1 km 187.5 (1971, gravel sand, granite, limestone), D1 km 187.6 (1971, gravel sand, granite, limestone), D1 km 188.85 (1971, gravel sand, granite, limestone),

Diamond ground - D1 km 228.348 (1992, gravel sand, granodiorite).

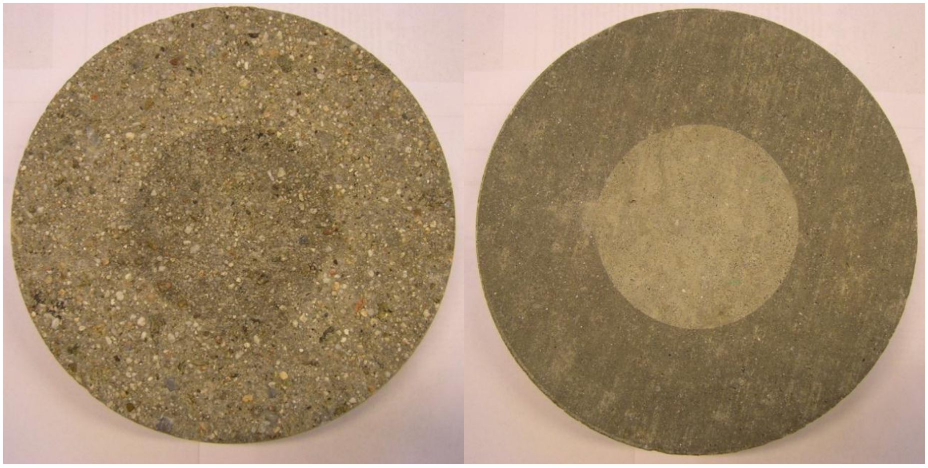

Fig. 9. (a) Example of PCC specimen after polishing from D1 km 187.6 (an old surface); (b) specimen D1 km 241 (a new surface)

We tested samples from the test sections of PCC surface showed in Figure 10 to find a friction durability of various surface treatments.

The first measurement of friction coefficient of new concrete pavements (before starting of polishing) often determines a good result and the abrasive effect of concrete pavements on rubber pads have been detected. Now we usually do not measure the PWS value before specimen polishing.

The worst PWS value demonstrated section D1 km 250. The surface was created by smooth cement mortar and the surface was very slippery especially in wet conditions. The PWS development showed that we cannot expect the skid resistance improvement with time. Cement mortar was not removed after 1 million specimen passes in the

W/S device and the aggregate with a good microtexture (greywacke) was still covered with mortar. It would be necessary to implement maintenance (for example pressure water jetting or diamond grooving).

Fig. 10. (a) Surface treatments aimed at the improvement of the skid resistance of PCC pavements: transverse use of nylon broom; (b) pressure water jet; (c) exposed aggregate [5]

Exposed greywacke aggregate did not reach the values which we expected. Macrotexture MTD (EN 13036-1) [6] was very good compared with other test sections but the aggregate used was covered with the cement mortar. PWS development during testing signals the expected benefit of the technology and aggregate.

The surface treated with pressure water jetting reached low values. From that it follows that the surface macrotexture was increased but natural sand grains in the surface were getting smoother and PWS decreased rapidly.

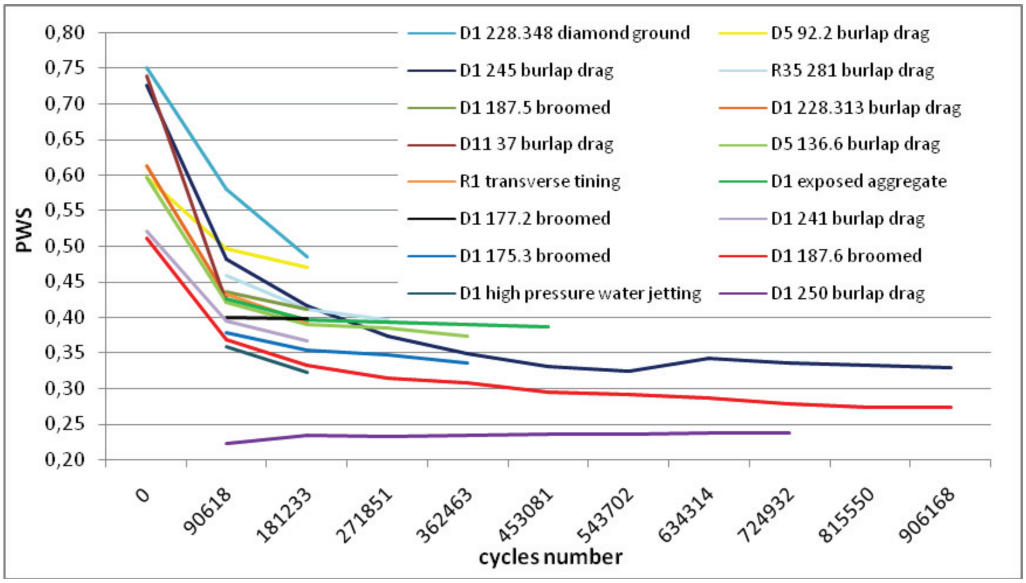

Fig. 11. Dependence of PWS values on cycles for PCC pavements

We tried to document the development of surface skid resistance by testing on the oldest D1 sections. Test sections were exposed to the effects of heavy goods vehicles (HGV) – more than 35 million during the last 40 years and surface was polished and caused very low skid resistance especially when coarse limestone aggregate was used. The test specimens D1 km 175.3 and km 187.6 contain more limestone grains on surface (than km 177.2 and km 187.5) that caused their low PWS values. The specimens taken from the edge of concrete slabs tested in W/S device document the similar effect as the traffic.

4. Conclusion

Test method according to EN 12697-49 [1] using the Wehner/Schulze test device was used in the study of the impact of traffic loading on pavement skid resistance.

The different types of aggregate granularity 8/11 mm were tested in the W/S test device and the results proved the better reliability than up to now used test method determining polished stone value PSV according to EN 1097-8. The W/S method is able to find the difference in polishing among the aggregates in case of similar results PSV (between PSV 49 and 52).

Both asphalt and PCC wearing courses were long term tested in the W/S device and the results showed accelerated decreasing of surface friction similarly as were determined on the real road surfaces. It was found that testing of real asphalt mixture is more reliable than testing of only aggregate or aggregate mixture with different polishing.

The results obtained by means of using the W/S proved that the device could be used as a performance test method forecasting the decreasing of skid resistance of wearing courses under traffic loading. It could be used especially in the development of a new material or technology of wearing courses.

Acknowledgements

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